

ELECTRIC MOTOR WITH ENCODER

## BACKGROUND OF THE INVENTION

## 5           1.    Field of the Invention

          The present invention relates generally to an electric motor and, more particularly, to an assembly of electric motor with encoder, which includes a shield grounding arrangement provided for a cable having a  
10   signal wire for outputting the detecting signal of the encoder and a shield member for shielding the signal wire.

## 2.    Description of the Related Art

          In an electric motor, an encoder provided for  
15   detecting positional data, such as the rotation angle of a motor shaft, has recently been developed so as to have detectability with higher precision and resolution, and accordingly, it is necessary to reduce the influence of noise on the output signal of the encoder sufficiently.  
20   Conventionally, for the purpose of reducing the influence of noise, a cable having therein a signal wire for outputting the detecting signal of the encoder (hereinafter referred to as an output signal cable) is provided with a shield member having a linear, network or  
25   film shape. The shield member provided in the output signal cable is generally electrically connected to the housing of the electric motor for grounding purposes.

          Japanese Unexamined Patent Publication (Kokai) No. 2002-354756 (JP2002-354756A) discloses an electric  
30   motor with encoder, wherein the output signal cable of the encoder is connected to a board connector on a circuit board of the encoder through a cable connector having a grounding wire. A shield member contained in the output signal cable is connected to the housing of  
35   the electric motor, through the mutual-connecting terminals of the cable and board connectors, a patterned conductor on the circuit board and the grounding wire of

the cable connector. The grounding wire is secured at the distal end thereof to the housing of the electric motor by a screw, whereby the shield member is electrically grounded.

5                    Japanese Unexamined Patent Publication (Kokai)  
No. 2002-101605 (JP2002-101605A) discloses an electric motor with encoder, wherein the output signal cable of the encoder is mounted on the housing of the electric motor through an electrical-conductive bush. A shield  
10 member contained in the output signal cable is partially exposed by removing a cable sheath, and is electrically connected to the motor housing for grounding purposes, by fixing the conductive bush to the exposed portion of the shield member as well as to the motor housing.

15                    Japanese Unexamined Patent Publication (Kokai)  
No. 10-239101 (JP10-239101A) discloses an electric motor with encoder, wherein a shield member provided in the lead wire of the electric motor is connected to an encoder cover. The shield member of the lead wire is  
20 electrically connected to the encoder cover for grounding purposes, by fixing the distal end of a shielding wire extending from the lead wire to the encoder cover by a screw.

#### SUMMARY OF THE INVENTION

25                    It is an object of the present invention to provide an improved shield grounding arrangement for an output signal cable in an electric motor with encoder, so as to facilitate a connecting operation of the output signal cable and to reduce operation costs.

30                    To accomplish the above object, the present invention provides an assembly of electric motor with encoder, comprising a motor housing; an encoder including a frame member attached to the motor housing in a conductive manner, a circuit board supported on the frame  
35 member and a detection circuit provided in the circuit board; an output signal cable connected to the circuit board of the encoder and including a signal wire and a

shield member; and a grounding mechanism electrically connecting the shield member of the output signal cable to the motor housing for grounding purposes; wherein the grounding mechanism includes a conductor patterned on the circuit board, a first connecting structure mutually  
5 connecting the conductor with the shield member, and a second connecting structure mutually connecting the conductor with the frame member.

In the above assembly of electric motor with  
10 encoder, the first connecting structure may comprise a first connector connected to the detection circuit and the conductor of the circuit board, and a second connector connected to the signal wire and the shield member of the output signal cable, the first connector  
15 and the second connector being able to be coupled with each other.

In this arrangement, the first connector may comprise a board connector mounted on the circuit board.

Also, the first connector may include a first  
20 conductive shell connected to the conductor, and the second connector may include a second conductive shell connected to the shield member, the second conductive shell being able to be coupled with the first conductive shell.

25 In this arrangement, the first connector may comprise an outer connector attached to an encoder cover enclosing the circuit board.

Further, the second connecting structure may comprise a through-hole plating provided in the circuit  
30 board to be connected with the conductor, the through-hole plating coming into conductive contact with the frame member.

In this arrangement, the second connecting structure may further comprise a fastening element inserted into a  
35 through hole having the through-hole plating and securing the circuit board onto the frame member.

Alternatively, the second connecting structure may

comprise a land provided on the circuit board to be connected to the conductor and a connecting element electrically connecting the land to the frame member.

5 In this arrangement, the connecting element may comprise a conductive fastening element securing the circuit board onto the frame member while coming into conductive contact with the land.

Also, the second connecting structure may comprise a conductive fastening element securing the circuit board  
10 onto the frame member while conducting with the conductor.

Alternatively, the second connecting structure may comprise a fastening element securing the circuit board onto the frame member in a condition where the conductor  
15 is brought into conductive contact with the frame member.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following description of preferred embodiments in  
20 connection with the accompanying drawings, of which:

Fig. 1 is an illustration schematically showing an embodiment of an assembly of electric motor with encoder, according to the present invention;

Fig. 2 is an illustration typically showing a  
25 detecting section in the assembly of electric motor with encoder as shown in Fig. 1;

Fig. 3A is a schematic plan view showing a grounding mechanism of the assembly of electric motor with encoder as shown in Fig. 1;

30 Fig. 3B is a schematic sectional view showing the grounding mechanism as shown in Fig. 3A;

Fig. 4A is an enlarged plan view showing a second connecting structure of the grounding mechanism as shown in Fig. 3A;

35 Fig. 4B is an enlarged sectional view showing the second connecting structure as shown in Fig. 4A;

Fig. 5A is an enlarged plan view showing a second

connecting structure of a grounding mechanism according to another embodiment;

Fig. 5B is an enlarged sectional view showing the second connecting structure as shown in Fig. 5A;

5 Fig. 6A is an enlarged plan view showing a second connecting structure of a grounding mechanism according to a further embodiment;

Fig. 6B is an enlarged sectional view showing the second connecting structure as shown in Fig. 6A;

10 Fig. 7A is an enlarged front view showing a part of a first connecting structure of a grounding mechanism according to a yet further embodiment;

Fig. 7B is an illustration schematically showing in an entirety the first connecting structure as shown in  
15 Fig. 5A;

Fig. 8A is a cross-sectional view showing an output signal cable, by way of example, usable for the assembly of electric motor with encoder as shown in Fig. 1; and

20 Fig. 8B is a vertical sectional view showing the output signal cable as shown in Fig. 8A.

#### DETAILED DESCRIPTION

The embodiments of the present invention are described below in detail, with reference to the accompanying drawings. In the drawings, the same or  
25 similar components are denoted by common reference numerals.

Referring to the drawings, Fig. 1 schematically shows an assembly 10 of electric motor with encoder, according to one embodiment of the present invention.  
30 The assembly 10 of electric motor with encoder includes an electric motor 14 having a motor housing 12, and an encoder 18 for detecting the rotation angle of an output shaft 16 of the electric motor 14. The encoder 18 includes a frame member 20 attached to the motor housing  
35 12 in an electrically conductive manner, a circuit board 22 supported on the frame member 20 and a detection circuit 24 (Fig. 2) provided in the circuit board 22.

The encoder 18 is disposed at the rear end region of the motor housing 12 with the circuit board 22 being covered by an encoder cover 26.

5 As typically shown in Fig. 2, the detection circuit 24 of the encoder 18 includes a light receiving element 28, such as a photodiode, and cooperates with a slit disc 30, attached to the output shaft 16 of the electric motor 14, and a light emitting element 32 and a fixed slit plate 34, arranged opposite to the light receiving  
10 element 28 with the disc 30 being disposed therebetween, so as to constitute an optical detecting section 36 of the encoder 18. It should be noted that the present invention does not restrict the constitution of the detecting section of the encoder, but may adopt detecting  
15 sections having various constitutions, such as a magnetic or the other optical type. Also, the present invention may be applied not only to a rotary motor with a rotary encoder as the illustrated embodiment, but also to a linear motor with a linear encoder incorporated  
20 therewith.

Referring again to Fig. 1, the assembly 10 of electric motor with encoder further includes an output signal cable 42 connected to the circuit board 22 of the encoder 18 and including a signal wire 38 and a shield  
25 member 40, and a grounding mechanism 44 electrically connecting the shield member 40 of the output signal cable 42 to the motor housing 12 for grounding purposes. The output signal cable 42 serves to transmit a detecting signal output from the detection circuit 24 of the  
30 encoder 18 to an outside control circuit (not shown) through the signal wire 38. The shield member 40, made of metal and having a linear, network or film shape, is disposed to surround the signal wire 38 inside a sheath 46 (see Figs. 8A and 8B), and serves to reduce the  
35 influence of noise on the detecting signal during transmission. In the assembly 10 of electric motor with encoder, a power line 48 is used for an electric power

supply to the electric motor 14.

As shown in Figs. 3A and 3B, the grounding mechanism 44 includes a conductor 50 patterned on the circuit board 22, a first connecting structure 52 mutually connecting  
5 the conductor 50 to the shield member 40, and a second connecting structure 54 mutually connecting the conductor 50 to the frame member 20. The grounding mechanism 44 serves to maintain the shield member 40 of the output signal cable 42 and the motor housing 12 at a common  
10 potential (or a ground potential). To this end, the motor housing 12 and the frame member 20 of the encoder 18 are made of good electrically conductive materials in at least the respective mutual-joint regions thereof. Further, the frame member 20, also called an encoder  
15 flange (or a flange base), is fixedly joined to the motor housing 12 by using a plurality of fastening elements 56, such as metal screws, so as to ensure the electrical conducting condition (or the ground potential) of the motor housing 12 and the frame member 20. In this  
20 respect, the motor housing 12 is grounded through an earth wire, etc. (not shown).

The conductor 50 of the grounding mechanism 44 is formed in a predetermined pattern on the surface of the circuit board 22 so as to extend between the first  
25 connecting structure 52 and the second connecting structure 54, by, e.g., a known manufacturing technology for printed circuit board wherein the wiring of the detection circuit 24 of the encoder 18 is patterned. The first connecting structure 52 includes a first connector  
30 58 connected to the detection circuit 24 and the conductor 50 of the circuit board 22 and a second connector 60 connected to the signal wire 38 and the shield member 40 of the output signal cable 42, the first connector 58 and the second connector 60 being able to be  
35 coupled with each other. In the illustrated embodiment, the first connector 58 is a board connector mounted on the surface of the circuit board 22, and one terminal

(not shown) in the first connector is connected to one end of the conductor 50. On the other hand, one terminal (not shown) in the second connector 60 as a cable connector is connected to the shield member 40. When the  
5 first and second connectors 58, 60 are properly coupled with each other, the terminal of the former connector, connected to the conductor 50, is connected to the terminal of the latter connector, connected to the shield member 40.

10 As shown in Figs. 4A and 4B, the second connecting structure 54 includes a through-hole plating 62 provided in the circuit board 22 to be connected with the conductor 50, and a fastening element 66 inserted into a through hole 64 having the through-hole plating 62. The  
15 through-hole plating 62 is provided integrally with a cylindrical portion 62a and a pair of land portions 62b, wherein the cylindrical portion 62a extends over the entire inner face of the through hole 64 penetrating between the opposite surfaces of the circuit board 22,  
20 while the land portions 62b extend on the opposite surfaces of the circuit board 22 along the peripheries of the opposite end openings of the through hole 64, one land portion 62b being connected to the conductor 50. The fastening element 66, formed as, e.g. a metal screw,  
25 has the same construction as a plurality of fastening elements 68 used for securing the circuit board 22 to the frame member 20.

Accordingly, when, for example, the fastening element 66 having an external thread 66a is inserted into  
30 the through hole 64 and is screwed into an internal thread 20a formed in the frame member 20, the circuit board 22 is secured to the frame member 20 and, simultaneously therewith, the through-hole plating 62 comes into electrical conductive contact with the frame  
35 member 20. Thus, the conductor 50 and the frame member 20 are electrically connected to each other through the through-hole plating 62. Consequently, the shield member



40 of the output signal cable 42, connected to the conductor 50 via the first connecting structure 52, is electrically connected to the frame member 20 of the encoder 18, connected to the conductor 50 via the second  
5 connecting structure 54. In this respect, the frame member 20 is attached to the motor housing 12 in a condition as for them to be electrically conductive with each other, as already described, and as a result of this, the shield member 40 is electrically connected to  
10 the motor housing 12 so as to be stably grounded.

It should be noted that, in the illustrated structure of the through-hole plating 62 having the pair of land portions 62b, the fastening element 66 made of an insulating material, such as a resin, may be used. On  
15 the other hand, if the fastening element 66 made of a good electrically conductive material, such as a metal, is used, the grounding performance of the second connecting structure 54 can be significantly enhanced. Also, if the through-hole plating 62 does not have the  
20 land portions 62b, or if a non-plated through hole is adopted, it is effective that a conductive fastening element 66 made of a good electrical conductive material is used so that, when the fastening element 66 is fastened to the frame member 20, the conductor 50 comes  
25 into electrical conductive contact, at the distal end thereof, with the fastening element 66.

As will be understood from the above, according to the grounding mechanism 44, it is possible to connect the shield member 40 with the conductor 50 at the same time  
30 as the signal wire 38 is connected with the detection circuit 24, during the step of connecting the output signal cable 42 to the circuit board 22 in the assembling process of the encoder 18. Also, it is possible to electrically connect the conductor 50 with the frame  
35 member 20 by using the fastening elements 66, 68 having common structures, during the step of securing the circuit board 22 to the frame member 20. Therefore, in

the assembly 10 of electric motor with encoder, it is enabled for the electrical connection between the shield member 40 of the output signal cable 42 and the motor housing 12 of the electric motor 14 to be readily  
5 established, without requiring a complicated operation such as a connecting operation for which a connection wire for the exclusive use of grounding purposes is provided. Consequently, according to the assembly 10 of electric motor with encoder, it is possible to facilitate  
10 a connecting operation of the output signal cable 42 and to reduce the operation costs thereof, so as to effectively reduce the cost and number of steps of assembling and manufacturing the assembly 10. It should be noted that an advantage is also obtained, wherein a  
15 cable termination processing such as the tearing off of the sheath 46 of the output signal cable 42 to expose the shield member 40 is eliminated, so that the waterproof properties of a cable connecting section are improved.

Although, in the above embodiment, the through hole plating 62 shown in Figs. 4A and 4B is used for the  
20 second connecting structure 54 for connecting the conductor 50 to the frame member 20, other means may be adopted therefor. For example, as shown in Figs. 5A and 5B, the second connecting structure 54 may include a land  
25 70 provided on the circuit board 22 to be connected with the conductor 50 and a connecting element 66' electrically connecting the land 70 to the frame member 20. In this embodiment, a non-plating through hole 72 is formed in the circuit board 22 to penetrate between the  
30 opposite surfaces thereof, and the land 70 extends annularly on one surface of the circuit board 22 along the periphery of one end opening of the non-plating through hole 72, the land 70 being patterned to be connected to the conductor 50. The connecting element  
35 66' is formed as a conductive fastening element 66' made of a good electrically conductive material, which has the same construction as the fastening elements 68 (Fig. 3A).

Accordingly, when, for example, the conductive fastening element 66' having an external thread 66a is inserted into the non-plating through hole 72 and is screwed into an internal thread 20a formed in the frame member 20, the circuit board 22 is secured to the frame member 20 and, simultaneously therewith, the head 66b of the fastening element 66' comes into conductive contact with the land 70 so as to electrically connect the land 70 to the frame member 20. Thus, the conductor 50 and the frame member 20 are electrically connected to each other through the land 70 and the conductive fastening element 66'. Consequently, the shield member 40 of the output signal cable 42, connected to the conductor 50 via the first connecting structure 52, is electrically connected to the frame member 20 of the encoder 18, connected to the conductor 50 via the second connecting structure 54. In this respect, the frame member 20 is attached to the motor housing 12 in a condition as for them to be electrically conductive with each other, as already described, and as a result of this, the shield member 40 is electrically connected to the motor housing 12 so as to be stably grounded.

Alternatively, as shown in Figs. 6A and 6B, the second connecting structure 54 may include a fastening element 66 securing the circuit board 22 onto the frame member 20 in a condition where the conductor 50 is brought into conductive contact with the frame member 20. In this embodiment, a non-plating through hole 72 is formed in the circuit board 22 to penetrate between the opposite surfaces thereof, and the conductor 50 is patterned to extend from the first connector 58 (Fig. 3B) to the back surface of the circuit board 22 so that the distal end of the conductor is in close proximity to the periphery of the opening of the non-plating through hole 72. In this respect, the conductor 50 formed by a manufacturing technology for printed circuit board is generally coated by a resist, so that it is necessary to

previously remove the resist on the desired length 50a of the distal end of the conductor.

Accordingly, when, for example, the fastening element 66 having an external thread 66a is inserted into  
5 the non-plating through hole 72 and is screwed into an internal thread 20a formed in the frame member 20, the circuit board 22 is secured to the frame member 20 and, simultaneously therewith, the conductor 50 on the back surface of the circuit board 22 comes into direct  
10 conductive contact with and is electrically connected to the frame member 20. Consequently, the shield member 40 of the output signal cable 42, connected to the conductor 50 via the first connecting structure 52, is electrically connected to the frame member 20 of the encoder 18,  
15 connected to the conductor 50 via the second connecting structure 54. In this respect, the frame member 20 is attached to the motor housing 12 in a condition as for them to be electrically conductive with each other, as already described, and as a result of this, the shield member 40 is electrically connected to the motor housing  
20 12 so as to be stably grounded.

Further, as the first connecting structure 52 mutually connecting the conductor 50 on the circuit board 22 with the shield member 40 of the output signal cable  
25 42, a system other than the above-described embodiment may be adopted. For example, as shown in Figs. 7A and 7B, as the first connector of the first connecting structure 52, an outer connector 74 attached to the encoder cover 26 enclosing the circuit board 22 may be  
30 adopted. The outer connector 74 is provided with a plurality of terminals 76 for output signals, and the terminals 76 are connected with the corresponding terminals (not shown) of a board connector 80 through an internal cable 78. One terminal (not shown) of the board  
35 connector 80 is connected to the conductor 50 (Fig. 3A) on the circuit board 22, whereby one terminal 76 of the outer connector 74 is electrically connected to the

conductor 50. On the other hand, the second connector 60 connected to the output signal cable 42 is provided with a plurality of terminal holes (not shown) individually connectable to the terminals 76 of the outer connector 74, and one terminal hole is connected to the shield member 40 (Fig. 8A). When the outer connector 74 is properly coupled with the second connector 60, the terminal 76 of the former connector, connected to the conductor 50, is connected to the terminal hole of the latter connector, connected to the shield member 40. It will be appreciated that the combination of the first connecting structure 52 having this arrangement and the above-described conductor 50 and second connecting structure 54 also ensure the grounding (i.e., the potential common to the motor housing 12) of the shield member 40 of the output signal cable 42.

In the first connecting structure 52 having the above arrangement, another constitution may be adopted wherein conductive shells of the outer and second connectors 74, 60 are assigned to a grounding line, instead of the constitution wherein one terminal 76 of the outer connector 74 and one terminal of the second connector 60 are assigned to the grounding line. In this arrangement, the outer (or first) connector 74 includes a first conductive shell 74a made of a good electrically conductive material, such as a metal, and the first conductive shell 74a is connected through the internal cable 78 to the corresponding terminal of the board connector 80, which in turn is connected to the conductor 50 (Fig. 3A) on the circuit board 22. Thus, the first conductive shell 74a of the outer connector 74 is electrically connected to the conductor 50. On the other hand, the second connector 60 includes a second conductive shell 60a made of a good electrically conductive material, such as a metal, which is connected to the shield member 40 (Fig. 8A). When the outer connector 74 is properly coupled with the second

connector 60, the first conductive shell 74a of the former connector, connected to the conductor 50, is conductively coupled with the second conductive shell 60a of the latter connector, connected to the shield member 40. It will be appreciated that the combination of the first connecting structure 52 having this arrangement and the above-described conductor 50 and second connecting structure 54 also ensure the grounding (i.e., the potential common to the motor housing 12) of the shield member 40 of the output signal cable 42.

While the invention has been shown and described particularly with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the following claims.